Intra Server

T E C H N O L O G Y ,   I N C .

ITIpci™ 5100G/GF
Gigabit Ethernet
Host Adapters for Solaris™

Installation and User's Guide

LSI LOGIC ®

T H E   C O M M U N I C A T I O N S   C O M P A N Y ™

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Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

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FCC Declaration of Conformity

The IntraServer Technology, Inc. ITIpci Gigabit Ethernet adapters, model numbers 5100G and 5100GF comply with the requirements of FCC part 15, class B as defined under paragraph 2.909 of these rules.

This declaration covers product identified with ITI 5100G and 5100GF on the product label.

A copy of the test report substantiating compliance is available on request from:

> Corporate EMC Manager
> IntraServer Technology, Inc.
> Seven October Hill Road
> Holliston, MA 01746

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Preface

This guide describes how to install and use the following IntraServer Technology ITI-5100G/GF adapters in the Solaris operating environment:

- PCI (Peripheral Component Interconnect) ITI-5100G Gigabit Ethernet for Copper adapter
- PCI (Peripheral Component Interconnect) ITI-5100GF Gigabit Ethernet for Fiber adapter

The procedures in this guide assume that you are a system or network administrator experienced in installing similar hardware in the Solaris environment.

How This Book Is Organized

This book is organized as follows:

"*About the ITI-5100G/GF Adapter*," describes the features of the ITI-5100G/GF adapter, and lists the hardware and software requirements for its installation and use.

"*Installing the ITI-5100G/GF Adapter*," explains how to physically install the adapter in your system.

"*The ITI-5100G/GF driver software*," explains how to install and configure the Gigabit Ethernet adapter software in the Solaris environment.

"*Optional Configuration*," explains how to configure the adapter for use with VLANs, Jumbo Frames, and Dual Homing.

"*Appendix*," provides adapter hardware, connector and cabling specifications, glossary and lists of figures and tables.

UNIX Commands

This document may not include all necessary software commands or procedures. Instead, it may name software tasks and refer you to operating system documentation or the handbook that was shipped with your workstation.

You might need to use supplemental documentation for the following types of information:

- Shutting down the system
- Booting the system
- Configuring devices
- Other basic software procedures

Typographic Conventions

Table 1 describes the meanings of the various typographic styles used in this book.

Typographic Conventions		
Typeface or Symbol	Meaning	Example
AaBbCc123	This type is used for names of commands, files, and directories used within the text.	View the readme.txt file.
	It also depicts on-screen computer output and prompts.	>> Main#
AaBbCc123	This bold type appears in command examples. It shows text that must be typed in exactly as shown.	>> Main# **sys**
AaBbCc123	This italicized type appears in command examples as a parameter placeholder. Replace the indicated text with the appropriate real name or value when using the command.	To establish a Telnet session, enter: host# **telnet** *IP-address*
	This also shows book titles, special terms, or words to be emphasized.	Read your User's Guide thoroughly.
[ ]	Command items shown inside brackets are optional and can be used or excluded as the situation demands. Do not type the brackets.	host# **ls [-a]**

Table 1: Typographic Conventions

Shell Prompts

Shell Prompts	
Shell	Prompt
C shell	machine_name %
C shell superuser	machine_name #
Bourne shell and Korn shell	$
Bourne shell and Korn shell superuser	#

Table 2: Shell Prompts

Contacting IntraServer Technology

Use the following information to access IntraServer Technology support and sales.

- URL for IntraServer Technology Online:

  http://www.intraserver.com

This website includes product information, software updates and release notes. The website also includes access to IntraServer Technology Customer Support for accounts under warranty or that are covered by a maintenance contract.

- E-mail access:

  support@intraserver.com

E-mail access to IntraServer Technology Customer Support is available to accounts that are under warranty or covered by a maintenance contract.

- Telephone access to IntraServer Technology Customer Support:

  1-508-429-0425 Extension 2

Telephone access to IntraServer Technology Customer Support is available to accounts that are under warranty or covered by a maintenance contract. Normal business hours are 8 a.m. to 6 p.m. Eastern Standard Time.

- Telephone access to IntraServer Technology Sales:

  1-508-429-0425 Extension 1

Telephone access is available for information regarding product sales and upgrades.

About the ITI-5100G/GF Adapter
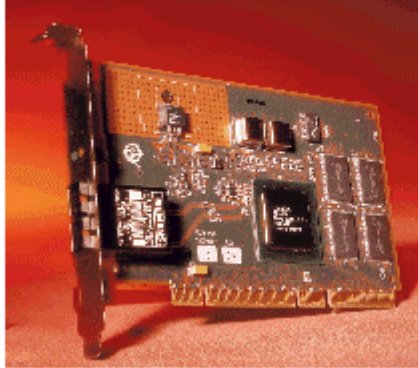
Figure 1: IntraServer Technology ITI-5100GF Gigibit Ethernet Fiber Interface Adapter

The ITI-5100GF adapter connects your PCI compliant server or workstation to a Gigabit Ethernet network. The adapter incorporates a technology that transfers data at a rate of one gigabit per second, 10 times the rate of a Fast Ethernet adapter. ITI-5100GF offers a Duplex SC fiber-optic connection.
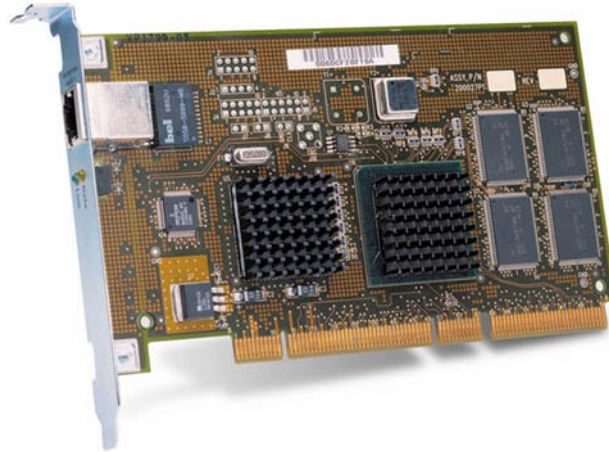
Figure 2: IntraServer Technology ITI-5100G Gigibit Ethernet Copper 10/100/100Base-T Interface Adapter

The ITI-5100G adapter connects your PCI compliant server or workstation to a Gigabit Ethernet network. The adapter incorporates a technology that transfers data at a rate of one gigabit per second, 10 times the rate of a Fast Ethernet adapter. ITI-5100G offers a Twisted Pair Copper interface, which is compatible with existing building (CAT-5) wiring systems. AutoSense speed selection allows operation at speeds of 10, 100 and 1000Mbits/sec, making the ITI-5100G ideal for upgrading existing networks to Gigabit Ethernet.

The ITI-5100G/GF adapter targets the increased congestion experienced at the backbone and server by today's networks, while providing a future upgrade path for high-end workstations that require more bandwidth than Fast Ethernet can provide.

Included with your adapter is the following:

- Anti-static bag (used for protecting the adapter when stored or shipped). Keep the adapter in its packaging until ready for installation.

- ITI-5100G/GF Gigibit Ethernet Adapter Software Distribution media containing ITI-5100G/GF adapter driver software and documentation

Inform your network supplier of any missing or damaged items. If you need to return the adapter, you must pack it in the original (or equivalent) packing material or the warranty will be voided.

Features

Following is a list of the Gigabit Ethernet PCI adapter features:

ITI-5100G and GF Models

- Full-duplex Gigabit Ethernet interface (IEEE P802.3-1999)
- Jumbo Frame support (optional 9,000 byte frames for server-to-server traffic)
- Standard Ethernet frame size (up to 1518 bytes)
- Dual Homing for automatic failover if a port, switch, or adapter is down
- VLANs: up to 64 VLANs per adapter using IEEE 802.1Q-1998 tagging
- Adaptive interrupt frequency (maximizes network throughput; adapts to traffic load)
- Dual DMA channels
- 33/66 MHz, 32-bit or 64-bit PCI bus master with adaptive DMA
- Universal dual voltage signaling (3.3V and 5V)
- PCI Local Bus Rev 2.1 compliant (6.8"x 4.2")
- ASIC with on-chip MAC and dual RISC processors
- Status LEDs

ITI-5100G Model

- CAT-5 compatible twisted pair Ethernet Connector
- Interoperability with existing Ethernet and Fast Ethernet Equipment

ITI-5100GF Model

- Duplex SC fiber-optic connector

Key Protocols and Interfaces

ITI-5100G/GF adapters are interoperable with existing Ethernet equipment assuming standard Ethernet minimum and maximum frame size (64 to 1518

bytes), frame format, and compliance with the following standards and protocols:

- Logical Link Control (IEEE 802.2)
- Flow Control (IEEE 802.3x)
- SNMP
- Gigabit Ethernet (IEEE P802.3z)

VLANs Support

Virtual Local Area Networks (*VLANs*) are commonly used to split up groups of network users into manageable broadcast domains, to create logical segmentation of workgroups, and to enforce security policies among logical segments.

Each ITI-5100G/GF adapter supports up to 64 VLANs. With multiple VLANs on an adapter, a server with a single adapter can have a logical presence on multiple IP subnets.

Refer to the *"Optional Configuration," section of this manual f*or configuration information.

Jumbo Frames Support

To reduce host frame processing overhead, the ITI-5100G/GF adapter and Gigabit switches that support jumbo frames, can receive and transmit frames that are larger than the maximum frame size allowed on normal Ethernet.

Dual Homing

Server switching networks require the capability to employ resiliency and redundancy similar to FDDI network environments. ITI-5100G/GF adapters provide the Ethernet user with this capability.

For dual homing support, you must install two ITI-5100G/GFs in the same host system. The adapters are configured to provide a hot-standby failover service. The switches must be configured to support Spanning Tree on both Gigabit Ethernet ports to support the ITI-5100G/GF Dual Homing capability.

Adaptive Interrupt Frequency

The adapter driver intelligently adjusts host interrupt frequency based on traffic conditions, in order to increase overall application throughput. In light traffic, the adapter driver interrupts the host for each received packet, minimizing latency. When traffic is heavy, the adapter issues one host

interrupt for multiple, back-to-back incoming packets, preserving host CPU cycles.

Dual DMA Channels

The PCI interface on the ITI-5100G/GF adapter contains two independent DMA channels for simultaneous read and write operations.

ASIC with Embedded RISC Processor

The core control for the ITI-5100G/GF adapter resides in a tightly integrated, high-performance ASIC. The ASIC includes dual RISC processors. This provides the flexibility to add new features to the card and adapt it to future network requirements via software download. This also enables the adapter drivers to exploit the built-in host off-load functions on the adapter as host operating systems are enhanced to take advantage of these functions.

Diagnostic Support

An ITI-5100G/GF adapter RISC CPU runs on-board diagnostics at power-up.

Physical Description
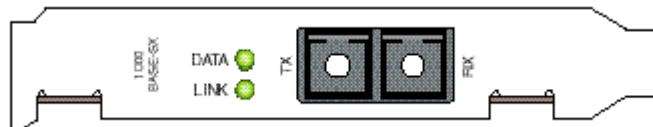
Figure 3: ITI-5100GF adapter faceplate

The faceplate of the ITI-5100GF adapter has one 1000Base-SX fiber-optic connector for connecting the adapter to a Gigabit Ethernet segment. There are also two LEDs: one to indicate link status and one for data transfer status.

Once the adapter hardware and its driver software have been properly installed on your system, the LEDs will signal the following adapter states:

ITI-5100GF Port LED Activity		
LED	State	Description
Data	Blinking	Data detected on the port.
	On	Data detected on the port.
	Off	No data detected on the port.
Link	Blinking slowly	Port has been disabled by software.

On	Good link.
Off	No link; possible bad cable, bad connector, missing or improperly installed driver software, or configuration mismatch.

Table 3: ITI-5100GF LED Status Indicators
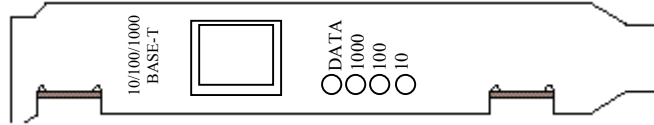
Figure 4: ITI-5100G adapter faceplate

The faceplate of the ITI-5100G adapter has one 10/100/1000Base-T twisted pair copper (CAT-5) connector for connecting the adapter to a Gigabit Ethernet segment. The adapter will also operate in an existing 10/100 Ethernet environment.

ITI-5100G Port LED Activity		
LED	**State**	**Description**
Data	Blinking	Data detected on the port.
	On	Data detected on the port.
	Off	No data detected on the port.
1000	On	Good link. at 1000Mb/sec
	Off	No link; possible bad cable, bad connector, missing or improperly installed driver software, or configuration mismatch.
100	On	Good link. at 100Mb/sec
	Off	No link; possible bad cable, bad connector, missing or improperly installed driver software, or configuration mismatch.
10	On	Good link. at 10Mb/sec
	Off	No link; possible bad cable, bad connector, missing or improperly installed driver software, or configuration mismatch.

Table 4: ITI-5100G LED Status Indicators

Installing the ITI-5100G/GF Adapter

The following instructions apply to installing the ITI-5100G/GF adapter in most servers. Refer to the manuals that were supplied with your server for details about performing these tasks on your particular system.

System Requirements

Before installing the ITI-5100G/GF adapter, make sure your system meets the requirements listed in the following table:

Hardware and Software Requirements	
Category	Requirements
Hardware	
PCI	All PCI based Sun^{TM} Systems
Firmware	OpenBoot^{TM} PROM version 3.0 or greater.
Software	
Operating System	Solaris 2.6 and later.
Adapter Software	ITI-5100G/GF 32-bit and 64-bit adapter driver software for Solaris. (see www.intraserver.com for driver updates)

Table 5: Hardware and Software Requirements

Safety Precautions

CAUTION:

- **The adapter is being installed in a server that operates with voltages that can be lethal. Before you remove the cover of your server, you must observe the following precautions to protect yourself and to prevent damage to the system components.**
- **Remove any metallic objects or jewelry from your hands and wrists.**
- **Make sure to use only insulated or non-conducting tools.**
- **Installation or removal of adapters must be performed in a static-free environment. The use of a properly grounded wrist strap or other personal anti-static devices and an anti-static mat is strongly recommended.**
- **Verify that the server is powered OFF before accessing internal components.**

Pre-Installation Checklist

1. Check that your server meets the hardware and software requirements listed in Table 5: Hardware and Software Requirements.

2. Review the information in the `readme` file on the ITI-5100G/GF Software Distribution media for important information not available at the time this manual was printed.

   Note: If you acquired the adapter software on a floppy disk or from the IntraServer Technology support website, please check the appropriate source for the most recent information.

3. If your system is active, execute proper shutdown.

4. When system shutdown is complete, power OFF your system.

5. Holding the adapter card by the edges, remove it from its shipping package it and place it on an anti-static surface.

6. Check the adapter for visible signs of damage, particularly on the card's edge connector. Never attempt to install any damaged adapter.

   If the adapter is damaged, report it to your IntraServer Technology Customer Support Representative. For more information, see Contacting IntraServer Technology.

PCI Adapter Installation

To install a PCI ITI-5100G/GF adapter in your system, perform the following procedure.

1. Observe all precautions and pre-installation instructions in the Safety Precautions section.

   Before installing the adapter, ensure the system power is OFF , and proper electrical grounding procedures have been followed.

2. Remove the server cover, and select any empty PCI slot.

   If you do not know how to identify a PCI slot, refer to your server documentation.

3. Remove the blank cover-plate from the slot that you selected. Retain the screw so that it can be replaced later.

4. Holding the PCI card by the edges, align the adapter's connector edge with the PCI connector dock in the server.

   Note: The connector dock in a 32-bit PCI slot is shorter than in a 64-bit PCI slot. Although the adapter is designed to fit in either slot type, when installed in a 32-bit PCI slot, part of the adapter's connector edge will remain undocked. This is perfectly normal.

5. Applying even pressure at both corners of the card, push the adapter card until it is firmly seated in the PCI slot.

   CAUTION: Do not use excessive force when seating the card, as this may damage the server or the adapter. If the card resists seating, remove it from the system, realign it, and try again.

   When properly seated, the adapter's port connectors will be aligned with the slot opening, and its faceplate will be flush against the server chassis.

6. Use the screw removed above (in Step 3) to secure the adapter in the PCI card cage.

7. Replace the server cover and disconnect any personal anti-static devices.

8. Power the server on.

   Once the server returns to proper operation, the adapter hardware is fully installed. You must next connect the network cables (see Connecting the Network Cables) and install the adapter driver software (see Installing the Driver Software).

Connecting the Network Cables

5100GF Cable Connection

The 5100GF adapter has one SC-type connector used for attaching the server to a Gigabit Ethernet fiber-optic segment. The port is auto-negotiating and supports full-duplex operation.

1. Prepare an appropriate cable.

The following table lists cable characteristics required for connecting to 1000Base-SX ports:

1000BASE-SX Link Characteristics		
Description	62.5 Micron	50 Micron
Frequency	Shortwave (850 nanometers)	Shortwave (850 nm)
Cable Type	Multimode fiber	Multimode fiber
Operating Range	2 to 260 meters	2 to 550 meters (in compliance with IEEE 802.3z)

Table 6: 1000BASE-SX Link Characteristics

2. As shown in the following diagram, connect one end of the cable to the ITI-5100G/GF adapter.
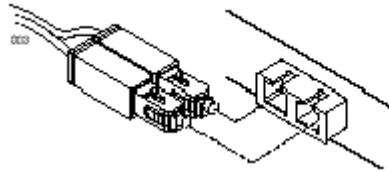
Figure 5: Connecting the network cable to the 5100GF adapter

3. Connect the other end of the cable to a Gigabit Ethernet network port.

    Attach the cable connector so that the TX (transmit) port on the ITI-5100G/GF adapter is connected to the RX (receive) port of the device at the other end of the cable.

    Note: The adapter port LEDs are not functional until the adapter driver software is installed. See Table 3 and Table 4 for a description of adapter port LED operation. See Installing the Driver Software *for driver installation and configuration instructions*.

5100G Cable Connection

The 5100G adapter has one RJ-45 connector used for attaching the server to an Ethernet twisted pair copper segment. The port is auto-negotiating and supports full-duplex operation.

1. Prepare an appropriate cable.

The following table lists cable characteristics required for connecting to 10/100/100 Base-T ports:

10/100/1000BASE-T Cable Specifications			
Port Type	**Connector**	**Media**	**Maximum Distance**
10Base-T	RJ-45	Cat. 3, 4 or 5 UTP	100 Meters
100/1000Base-T	RJ-45	Cat. 5 UTP	100 Meters

Table 7: 10/100/1000BASE-T Cable Specifications

2. Connect one end of the cable to the ITI-5100G/GF adapter.

3. Connect the other end of the cable to a Gigabit Ethernet network port.

    Note: The adapter port LEDs are not functional (they will not reflect port link or data status) until the adapter driver software is installed.

The ITI-5100G/GF Driver Software

A network device driver must be installed before the ITI-5100G/GF adapter can be used with your systems. This chapter describes how to preform the following tasks:

- Install the driver software in the Solaris environment

- Configure the host files

- Configure driver parameters using the *ndd* utility

Installing the Driver Software

Note: The ITI-5100G/GF adapter must be physically installed in your server prior to installing the driver software. See "Installing the ITI-5100G-GF Hardware," for details.

To install the adapter software for Solaris, perform the following procedure:

1.   Become superuser (*root*).

2.   Note the revision level of the Software Distribution Media included with your IntraServer Technology adapter.

        The revision level is stamped on the Software Distribution Media label and is used in the commands below.

Place the Software Distribution Media into the CD-ROM drive.

Mount the CD-ROM on a local directory.

- If the Volume manager (*vold*) is running on your machine, when the ITI-5100G/GF CD-ROM is loaded into the drive, it is mounted automatically under */cdrom/cdrom0*
  #volcheck

Access the package directory by entering the following:

 # cd /cdrom/cdrom0

■

At the prompt, type the *pkgadd* command:

pkgadd -d .

The screen displays a list of packages available for installation:

```
The following packages are available:
1 ITIalt IntraServer/LSI Logic 32/64-bit Gigabit
Ethernet Adapter
         (sparc)Kit Version x.x

Select package(s) you wish to process (or `all' to
process all packages). (default: all) [?, ??, q]
```

Type the number for the *ITIalt* driver and press Return.

The *pkgadd* command starts the installation script.

Do not select the *default: all* option to install "all" drivers. Install only the driver appropriate for your system: *ITIalt* .

Respond to prompts in the script.

pkgadd keeps cycling through its script once it has started. Therefore you must quit (*q*) the program the second time the list of packages is displayed.

When you have finished loading the software, eject the CD-ROM by entering the following commands:

cd /
eject cdrom

Troubleshooting: If the Driver Fails to Attach

If the adapter is not installed, you will see the following message when you run *pkgadd* :

```
drvconfig: Driver (alt) failed to attach
Warning: Driver (alt) successfully added to system
but failed to attach
pkgadd: ERROR: postinstall script did not complete
successfully
```

If this happens, halt your machine using the following commands:

```
# sync
# sync
# halt
```

Then, at the *ok* prompt, use the following command to list the system devices:

```
ok show-devs
```

ITI-5100G/GF adapter output will be displayed. Sample PCI examples are shown on the next page.

For PCI systems, " *ethernet@1* " identifies the PCI ITI-5100G/GF adapter:

```
/SUNW,ffb@1e,0
/SUNW,UltraSPARC-II@0,0
/pci@1f,2000
/pci@1f,4000
/counter-timer@1f,1c00
/virtual-memory
/memory@0,60000000
/aliases
/options
/openprom
/chosen
/packages
/pci@1f,2000/ethernet@1
/pci@1f,4000/scsi@3
/pci@1f,4000/network@1,1
/pci@1f,4000/ebus@1
/pci@1f,4000/scsi@3/tape
/pci@1f,4000/scsi@3/disk
/pci@1f,4000/ebus@1/SUNW,CS4231@14,200000
....
```

If the appropriate ITI-5100G/GF device is not listed, check that the adapter is installed and properly seated. Then restart the system and re-install the adapter software.

Configuring the Host Files

Once the ITI-5100G/GF adapter software is installed on your system, it must be configured. To ensure proper adapter performance, configure the host files and driver parameters as described in the following sections.

Note: If any adapter card is moved from one slot to another, the **alt** *instance values in the* **/etc/path_to_inst** *file will be incorrect. Correct the instance values before making any adapter configuration changes. See your Solaris manuals for details on setting instance values.*

- Each adapter must be assigned a host name and an IP address. If you are not using multiple VLANs, perform the steps below when configuring the host name and IP address for your adapter.

- If VLANs are to be used, any specific adapter may have one host name and IP address for each VLAN. If you will be using VLANs on the network, see the Configuring VLANs section of this manual.

1. Create the */etc/hostname.alt <num>* file(s) on the server.

   There can be up to four adapters per server. Create one */etc/hostname.alt <num>* file for each adapter. The number *<num>* in the filename is determined as follows:

Hostname Numbering	
Adapter	Hostname
First	/etc/hostname.alt0
Second	/etc/hostname.alt1
Third	/etc/hostname.alt2
Fourth	/etc/hostname.alt3

   For example, the first adapter in the server requires a file named */etc/hostname.alt0* and the second adapter requires a file named */etc/hostname.alt1* .

2. Place the appropriate adapter host name into the *hostname.alt <num>* file(s).

   The */etc/hostname.alt <num>* file must contain the appropriate host name for the adapter. The host name should be different from that of any other interface. For example, */etc/hostname.alt0* and */etc/hostname.alt1* cannot share the same host name.

   The following example depicts the host name files required for a machine called *iti* , with ITI-5100G/GF adapters known as *iti-1* , *iti-2* , *iti-3* , and *iti-4* on the networks created for *alt0* , *alt1* , *alt2* , and *alt3* .

```
iti # cat /etc/hostname.alt0
iti-1
iti # cat /etc/hostname.alt1
iti-2
iti # cat /etc/hostname.alt2
iti-3
iti # cat /etc/hostname.alt3
iti-4
```

3. For each host name, enter the appropriate IP address in the
    `/etc/hosts` file.

4. Reboot the system.

If you make changes and put the system into service before rebooting, you
may experience configuration problems.

Perform this command to reboot the system:

reboot -- -r

Configuring Driver Parameters with ndd

The *ndd* (1M) utility is useful for changing configuration parameters for the
adapter. Alternately, adapter parameters can be changed by manually editing
the configuration files. This section describes the *ndd* utility in detail.

Note: Any changes made with **ndd** *are temporary and will be lost when
you reboot the system. To make configuration changes survive the reboot
process, you will need to store driver settings in the*
/etc/rc2.d/S99itialt *file (see Saving Driver Parameters Beyond
Reboot).*

Available Parameters

To view parameters that you can set using the *ndd* command, type:

ndd /dev/alt '?'

The system returns the following:

```
stat_ticks (read and write)
send_max_coalesced_bds (read and write)
send_coal_ticks (read and write)
recv_max_coalesced_bds (read and write)
```

```
recv_coal_ticks (read and write)
nic_tracing (read and write)
link_negotiation (read and write)
dump_nic (read and write)
jumbo (read and write)
vlan? (read and write)
vlan_tag (read and write)
vlan_tag_id (read and write)
redund? (read and write)
redund (read and write)
fdr_filter (read and write)
rx_flow_control (read and write)
tx_flow_control (read and write)
hybrid_len (read and write)
shared_rupt (read and write)
snap (read and write)
instance (read and write)
```

The following table describes the driver parameters available through *ndd* .

Adapter Driver Parameters	
Parameter	Meaning
stat_ticks	Minimum number of 1 sec ticks between statistics updates. 0 (off) is the minimum, and 100,000 is the default. There is no maximum.
send_max_coalesced_bds	Number of sends before a send complete event is set. 1 is the minimum, 127 is the maximum, and 60 is the default. WARNING: Setting this to an improper value can result in driver performance degradation or failure.
send_coal_ticks	(Do not use; value is set by startup file)
recv_max_coalesced_bds	Maximum number of receives that can be bundled into an event. 1 is the minimum, 511 is the maximum, and 6 is the default. WARNING: Setting this to an improper value can result in degraded performance.
nic_tracing	(Not currently used)
link_negotiation	Used to set IEEE 802.3z Link Negotiation to auto or off. Use a value of 0 for off, or 1 for auto. The default is 1 (auto).
dump_nic	(Do not use; reserved for debugging)
jumbo	(Do not use; value is set by startup file)
vlan?	(Do not use; value is set by startup file)
vlan_tag	(Do not use; value is set by startup file)
vlan_tag_id	(Do not use; value is set by startup file)
redund?	(Do not use; value is set by startup file)
redund	(Do not use; value is set by startup file)
fdr_filter	Full-Duplex Repeater Filter. For older adapters (Model 710002), turn this on if the adapter is attached to a Full-Duplex Repeater. Use a value of 0 for off, or 1 for on. The default is 0 (off).
rx_flow_control	If link negotiation is on, a value of 1 allows the adapter to negotiate 802.3x receive flow control with the device at the other end of the link. If 802.3x flow control is supported by the other device, receive pause packets will be respected. A value of 0 disables receive flow control. The default is 1 (on).

Adapter Driver Parameters	
Parameter	Meaning
tx_flow_control	If link negotiation is on, a value of 1 allows the adapter to negotiate 802.3x transmit flow control with the device at the other end of the link. If 802.3x flow control is supported by the other device, transmit pause packets will be respected. A value of 0 disables transmit flow control. The default is 0 (off).
hybrid_len	(Do not use; value is set by startup file)
shared_rupt	(Do not use; value is set by startup file)
snap	(Do not use; value is set by startup file)
instance	Used to set the device number from which the previous data is extracted. This value can range from 0 to the number of adapters installed in the system. The default is 0.

Table 8: Adapter Driver Parameters

Checking Parameter Settings

To check a current parameter setting, use the following command:

ndd /dev/alt *<parameter_name>*

Setting Parameters

Follow this procedure to set parameters using the *ndd* utility:

1. Check the */etc/path_to_inst* file for the instance associated with particular devices.

2. Specify the instance for the adapter you wish to configure:

ndd -set /dev/alt instance *<instance#>*

Any subsequent *ndd* configuration commands will act on the adapter with the selected instance. The adapter remains selected until you specify a different instance.

3. Specify the configuration command using the following format:

ndd -set /dev/alt *<parameter>* *<value>*

A list of valid parameters and values can be found in Available Parameters.

Note: Any changes made with **ndd** *will be lost when you reboot the system. To make configuration changes survive reboot, store driver settings in the* `/etc/rc2.d/S99itialt` *file (see Saving Driver Parameters Beyond Reboot).*

Link Negotiation

The default configuration for link negotiation of the Gigabit Ethernet link is *auto* . With this setting the ITI-5100G/GF adapter will use IEEE 802.3-1998 auto negotiation.

If you are connecting the adapter to Gigabit Ethernet equipment that does not support auto negotiation, or if there is a problem establishing a link between the two devices, auto negotiation can be turned off (see Available Parameters).

Increasing TCP/IP Performance

The TCP/IP performance of the ITI-5100G/GF PCI adapter can be increased by changing the TCP/IP *ndd* values. This can be done with the *ndd* (1M) utility, as described below.

Enter the following *ndd* commands to increase TCP/IP performance:

```
# ndd -set /dev/tcp tcp_recv_hiwat 65535
# ndd -set /dev/tcp tcp_xmit_hiwat 65535
# ndd -set /dev/udp udp_recv_hiwat 65535
# ndd -set /dev/udp udp_xmit_hiwat 65535
```

To avoid losing these settings when reboot occurs, add your *ndd* parameter settings to the start-up file as described in the following section, Saving Driver Parameters Beyond Reboot.

Saving Driver Parameters Beyond Reboot

Any parameter changes made using *ndd* will be lost the next time your system is rebooted. To keep changes through reboot, parameter settings must be placed in a start-up file with the following filename:

/etc/rc2.d/S99itialt

Example: If you need to adjust adapter 2 to turn Link Negotiation off and increase the TCP/IP values, you could place the following lines in the */etc/rc2.d/S99itialt* start-up file:

```
#!/sbin/sh
# local kernel modification

#


case "$1" in
'start')

echo "Setting local kernel parameters...\c"
ndd -set /dev/alt instance 2
ndd -set /dev/alt link_negotiation 0
ndd -set /dev/tcp tcp_recv_hiwat 65535
ndd -set /dev/tcp tcp_xmit_hiwat 65535
ndd -set /dev/udp udp_xmit_hiwat 65535
ndd -set /dev/udp udp_recv_hiwat 65535
echo " "
;;

'stop')
echo "$0: No parameters changed."
;;

*)
echo "Usage: $0 {start|stop}"
;;

esac
```

Optional Configuration

Your IntraServer Technology ITI-5100G/GF adapter can be configured to support the following options:

- VLANs: Virtual Local Area Networks (VLANs) are commonly used to split up groups of network users into manageable broadcast domains, to create logical segmentation of workgroups, and to enforce security policies among each logical segment. Up to 64 VLANs can be defined for each ITI-5100G/GF adapter on your server

- Jumbo Frames: Standard Ethernet frames are 1,500 bytes long. When sending Ethernet traffic at Gigabit speeds, a considerable portion of the bandwidth is consumed by the overhead of handling a multitude of small packets. ITI-5100G/GF adapters support Ethernet frames of 9,000 bytes. Host CPU utilization is significantly reduced and network throughput is enhanced when enabling Jumbo Frames between servers that have ITI-5100G/GF adapters and switches that support Jumbo Frames.

- Dual Homing: Two ITI-5100G/GF adapters on a server can be paired for redundant operation through the use of the Dual Homing feature. If traffic on a primary connection is lost due to the failure of the adapter, cable, switch port, or switch (when the dual adapters are attached to separate switches), the secondary adapter becomes active and assumes the MAC and IP address of the primary adapter. Network sessions should be maintained after the switchover, causing minimum impact to network traffic.

This chapter describes these options in detail, with configuration instructions and examples. If your network does not require VLANs, Jumbo Frames, or Dual Homing, you need only configure the adapter to support the default configuration, as described in "The ITI-5100G/GF Driver Software".

Note: If you modify any of the optional configuration parameters (VLANs, Jumbo Frame, or Dual Homing), you must reboot the system before the changes will take effect. If you make changes and do not reboot, you may experience configuration problems.

VLANs

VLANs allow you to split your physical LAN into logical subparts, providing an essential tool for increasing the efficiency and flexibility of your network.

Overview

Each defined VLAN behaves as its own separate network, with its traffic and broadcasts isolated from the other VLANs to increase bandwidth efficiency within each logical group. One example of how VLANs can be used to segment a LAN is when isolating different types of network traffic. If you wanted to utilize Jumbo Frames on a portion of your LAN, you could configure one VLAN for devices that support Jumbo Frames, and a separate VLAN for devices supporting only standard frames. By implementing VLANs, you could segregate the different frame types from each other without reorganizing your LAN into separate physical subnets.

Although VLANs are commonly used to create individual broadcast domains and/or separate IP subnets, it is sometimes useful for a server to have a presence on more than one VLAN simultaneously. Alteon WebSystems switches and ITI5100G/GF adapters support multiple VLANs on a per-port or per-interface basis, allowing very flexible network configurations.

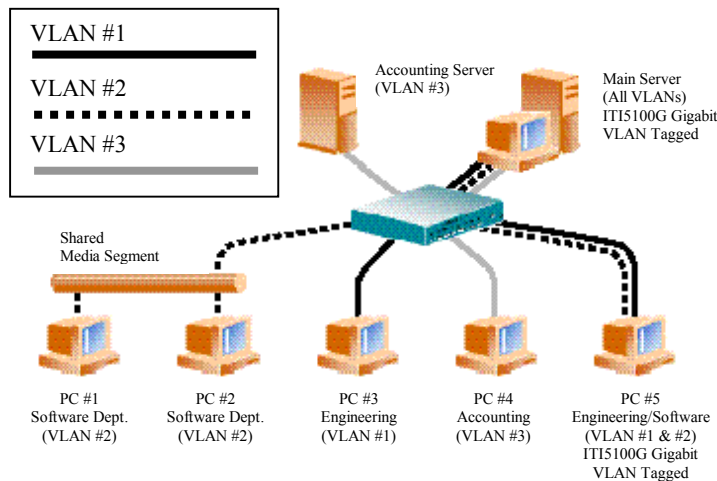See Figure 6 for an example of servers supporting multiple VLANs with Tagging.

Figure 6: Servers Supporting Multiple VLANs

In the example network shown in Figure 6, the physical LAN consists of a switch, two servers, and five clients. The LAN is logically organized into three different VLANs, each representing a different IP subnet. The features of this network are described in the following table.

Example VLAN Network Topology	
Component	Description
VLAN #1	An IP subnet consisting of the Main Server, PC #3, and PC #5. This subnet represents an engineering group.
VLAN #2	Includes the Main Server, PCs #1 and #2 via shared media segment, and PC #5. This VLAN is a software development group.
VLAN #3	Includes the Main Server, the Accounting Server and PC #4. This VLAN is an accounting group.
Main Server	A high-use server that needs to be accessed from all VLANs and IP subnets. The Main Server has an ITI5100G adapter installed. All three IP subnets are accessed via the single physical adapter interface. The server is attached to an Alteon WebSystems switch Gigabit Ethernet port, which is configured for VLANs #1, #2, and #3. Both the adapter and the connected switch port have tagging turned on. Because of the tagging VLAN capabilities of both devices, the server is able to communicate on all three IP subnets in this network, but continues to maintain broadcast separation between all of them.
Accounting Server	Available to VLAN #3 only. The Accounting Server is isolated from all traffic on VLANs #1 and #2. The switch port connected to the server has tagging turned off.
PCs #1 and #2	Attached to a shared media hub that is then connected to the switch. PCs #1 and #2 belong to VLAN #2 only, and are logically in the same IP subnet as the Main Server and PC #5. The switch port connected to this segment has tagging turned off.
PC #3	A member of VLAN #1, PC #3 can communicate only with the Main Server and PC #5. Tagging is not enabled on PC #3's switch port.
PC #4	A member of VLAN #3, PC #4 can only communicate with the servers. Tagging is not enabled on PC #4's switch port.
PC #5	A member of both VLANs #1 and #2, PC #5 has an ITI5100G adapter installed. It is connected to switch port #10. Both the adapter and the switch port are configured for VLANs #1 and #2 and have tagging enabled.

Table 9: Example VLAN Network Topology

VLAN tagging is only required to be enabled on switch ports that create trunk links to other VLAN capable switches, or on ports connected to tag-capable end-stations, such as servers or workstations with ITI5100G/GF adapters.

Configuring VLANs

By default, Alteon WebSystems switches have a single VLAN configured for every port, which groups all ports into the same broadcast domain, just as if there were no VLANs at all. This default VLAN has an 802.1Q-1998 VLAN identification number of [1], with VLAN tagging for the switch port turned off.

If you are using a VLAN capable switch from another manufacturer, consult the documentation for your switch before continuing.

To configure VLANs, perform the following procedure:

Note: If you configure a VLAN for an adapter, all traffic sent or received by that adapter must be in VLANs.

1. Create the */etc/hostname.alt* file(s) on the server.

    There can be up to four adapters per server, and up to 64 VLANs defined per adapter.

    One */etc/hostname.alt* *<num>* file must be created for each VLAN that will be configured for each adapter on the server. Create files using the following naming format:

    /etc/hostname.alt *<num>*

    For each file, the number *<num>* in the filename is determined according to the table below. For example, the first adapter in the server requires a file named */etc/hostname.alt0* for its first VLAN, and a file named */etc/hostname.alt100* for its second VLAN.

Up to 64 VLANs	First Adapter	Second Adapter	Third Adapter	Fourth Adapter
1	/etc/hostname .alt0	/etc/hostname .alt1	/etc/hostname .alt2	/etc/hostname .alt3
2	/etc/hostname .alt100	/etc/hostname .alt101	/etc/hostname .alt102	/etc/hostname .alt103
3	/etc/hostname .alt200	/etc/hostname .alt201	/etc/hostname .alt202	/etc/hostname .alt203

...				
64	/etc/hostname .alt6300	/etc/hostname .alt6301	/etc/hostname .alt6302	/etc/hostname .alt6303

Table 10: Creating the /etc/hostname.alt<num> files

2. Place the appropriate adapter host name into the
   `/etc/hostname.alt` file(s).

   The `/etc/hostname.alt` *<num>* file must contain the appropriate
   adapter host name.

   The host name should be different from the host name of any other
   interface. For example, `/etc/hostname.alt0` and
   `/etc/hostname.alt100` cannot share the same host name.

   The following example depicts the host name files required for a
   machine called *iti* , with one ITI5100G/GF adapter with four VLANs:

   iti # *cat /etc/hostname.alt0*
   iti-1
   iti # *cat /etc/hostname.alt100*
   iti-1100
   iti # *cat /etc/hostname.alt200*
   iti-1200
   iti # *cat /etc/hostname.alt300*
   iti-1300

3. For each host name, enter the appropriate IP address in the
   `/etc/hosts` file.

4. Create the `/etc/vlan.alt` *<num>* file(s).

   One corresponding `/etc/vlan.alt` *<num>* file is needed for each
   `/etc/hostname.alt` *<num>* file created in the previous steps (one
   for each VLAN being configured for each adapter on the server). Create
   files using the following naming format:

   /etc/vlan.alt *<num>*

   For each file, the number *<num>* in the filename is determined according
   to the table below. For example, the first adapter requires a file named
   `/etc/vlan.alt0` for its first VLAN, and a file named
   `/etc/vlan.alt100` for its second VLAN.

Up to 64 VLANs	First Adapter	Second Adapter	Third Adapter	Fourth Adapter
1	/etc/vlan.alt0	/etc/vlan.alt1	/etc/vlan.alt2	/etc/vlan.alt3
2	/etc/vlan.alt100	/etc/vlan.alt101	/etc/vlan.alt102	/etc/vlan.alt103
3	/etc/vlan.alt200	/etc/vlan.alt201	/etc/vlan.alt202	/etc/vlan.alt203
...				
64	/etc/vlan.alt6300	/etc/vlan.alt6301	/etc/vlan.alt6302	/etc/vlan.alt6303

Table 11: Creating the /etc/vlan.alt<num> files

5. Place the appropriate VLAN ID tag into the $vlan.alt$ *<num>* file(s).

Each VLAN must be assigned a unique identification number. Even though the maximum number of VLANs that can be configured on each adapter is 64, any particular VLAN can be assigned an identification number between 1 and 4094. The VLAN tagging format follows the guidance provided in IEEE 802.1Q-1998.

The VLAN identifier numbers must be placed into each appropriate $vlan.alt$ *<num>* file to which the adapter is a member.

Example: Consider a server with a single adapter. The server is a member of two VLANs, with VLAN identifiers 383 and 777. The contents of the first file, /etc/vlan.alt0 , would be "383" and the contents of the second file, /etc/vlan.alt100 , would be "777".

Use your regular text editor to put the VLAN identifier number into the appropriate $vlan.alt$ *<num>* file. Be certain that there are no spaces, blank lines, or extra characters. The identifier can be entered in decimal (e.g. 383), octal (e.g. 0577), or hexadecimal (e.g. 0x17F) format.

If you are finished with all optional configurations, reboot the system.

Changes to the optional configuration parameters (VLAN, Jumbo Frame, or Dual Homing) do not take effect until you reboot the system. If you will be making changes to the other optional parameters during your configuration session, you should wait to reboot until those changes are complete.

If you modify parameters and put the system into service before rebooting, you may experience configuration problems.

Perform this command to reboot the system:

```
# reboot -- -r
```

Verify the configuration changes.

Enter the following command and verify that the appropriate VLANs are present:

```
# ifconfig -a
```

Jumbo Frames Support

ITI-5100G/GF adapters support Jumbo Frames--frames of up to 9,000 bytes that are sent between servers that have ITI-5100G/GF adapters and switches that support Jumbo Frames. Host CPU utilization is significantly reduced and network throughput is enhanced by sending 9,000 byte frames rather than the standard 1,500 byte Ethernet frames.

Overview

A single ITI-5100G/GF adapter on a server can support standard Ethernet frames as well as Jumbo Frames. Jumbo Frames are only sent between servers that have ITI-5100G/GF adapters. Standard Ethernet frames are used between servers that have ITI-5100G/GF Adapters and all other Ethernet devices.

Note: Not all network switches support passing Jumbo Frames. Check with your switch manufacturer for confirmation of Jumbo Frame support.

Configuring Jumbo Frames Support

To configure Jumbo Frame support, perform the following procedure:

1. Create the */etc/jumbo.alt* *<num>* file.

2. Use your regular text editor to put the number "*9000*" into the */etc/jumbo.alt* *<num>* file.

    Put the number "*9000*" in the file, without spaces or blank lines.

3. If you are finished with all optional configuration, reboot the system.

    Changes to the optional configuration parameters (Jumbo Frame, or Dual Homing) do not take effect until you reboot the system. If you will be making changes to the other optional parameters during your configuration session, you should wait to reboot until those changes are complete.

Note: If you modify parameters and put the system into service before rebooting, you may experience configuration problems.

Perform this command to reboot the system:

reboot

4.   Verify the configuration changes.

Enter the following command and verify that the MTU size is set to 9000:

ifconfig -a

Dual Homing

When two ITI-5100G/GF adapters are installed in the same server, they can be paired in a Dual Homing configuration. If traffic is not seen over the primary adapter connection due to loss of the adapter, cable, switch port, or switch (where the two adapters are attached to separate switches), the secondary adapter becomes active. When it becomes active, the secondary adapter uses the MAC and IP address originally assigned to the primary adapter. Sessions should be maintained, with minimum impact to network traffic.

Overview

The Dual Homing feature relies on the Spanning Tree Protocol. Adapters configured for Dual Homing allow Spanning Tree Protocol packets to pass between them. This causes the Spanning Tree Protocol to detect a loop in the network, forcing the switch port connected to one of the adapters to go into blocking mode. The blocked adapter becomes the secondary.
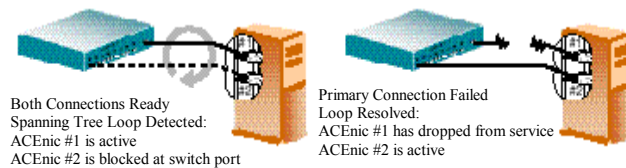

Both Connections Ready
Spanning Tree Loop Detected:
ACEnic #1 is active
ACEnic #2 is blocked at switch port

Primary Connection Failed
Loop Resolved:
ACEnic #1 has dropped from service
ACEnic #2 is active

Figure 7: Dual Homing with Spanning Tree

If the primary connection becomes disabled for any reason, the Spanning Tree Protocol will detect the loss of the loop, and will change the switch port connecting the secondary adapter from blocking mode to forwarding mode.

Configuring Dual Homing

To configure Dual Homing in a system with two adapters, where
/etc/hostname.alt0 is the primary adapter, perform the following
procedure:

*Note: Do not configure an /etc/hostname.alt<num> entry for the
redundant adapter*. Also, do not configure Jumbo Frame support files for
the redundant adapter. If the primary adapter fails, the secondary adapter
takes on the configuration of the primary adapter. Serious configuration
problems will occur if there are hostname or Jumbo Frame configuration files
for the secondary adapter.

1. Enable Spanning Tree Protocol on the switch connected to your ITI-
    5100G/GF adapters.

2. The port to which the secondary adapter is connected must be the port
    that blocks.

    If there is more than one switch in the spanning tree, be certain that the
    secondary adapter is not attached to the root switch of the spanning tree.
    Also, be sure that the port path cost of the switch port connected to the
    secondary adapter is higher than the other ports in the loop.

    Example: In the following redundant switch configuration, the switch
    port connected to adapter #2 must have the highest port path cost of any
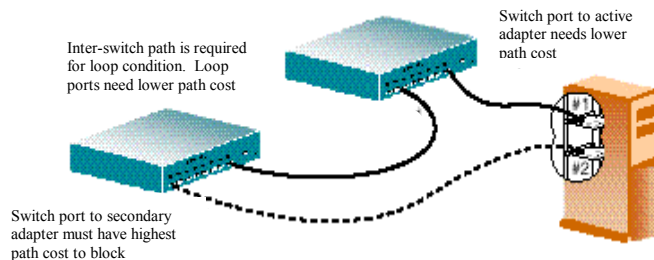   of the four ports in the loop:

Figure 8: Dual Homing Path Costs

3. Create the */etc/redund.alt1* file.

4. Use your regular text editor to put the number " *0* ", the instance
    number of the primary adapter, into the file */etc/redund.alt1* .

    Put the number " *0* " in the file, without spaces or blank lines.

5. If you are finished with all optional configuration, reboot the system.

Changes to the optional configuration parameters (Jumbo Frame, or Dual Homing) do not take effect until you reboot the system. If you will be making changes to the other optional parameters during your configuration session, you should wait to reboot until those changes are complete.

Note: If you modify parameters and put the system into service before rebooting, you may experience configuration problems.

Perform this command to reboot the system:

```
# reboot -- -r
```

Appendices

Appendix A

1000BASE-SX Link Characteristics

Description	62.5 Micron	50 Micron
	Shortwave (850 nanometer multimode fiber)	
Operating Range	2 to 260 meters	2 to 550 meters (in compliance with IEEE 802.3-1998)

10/100/1000BASE-T Cable Specifications

Port Type	Connector	Media	Maximum Distance
10Base-T	RJ-45	Cat. 3, 4 or 5 UTP	100 Meters
100/1000Base-T	RJ-45	Cat. 5 UTP	100 Meters

Performance Specifications

Feature	Specification
PCI clock	66 MHz max
PCI Data/Address	32- and 64-bit
PCI data burst transfer rate	132 MB/second (32-bit bus) 264 MB/second (64-bit bus) 528 MB/second (64-bit bus at 66 MHz)
PCI modes	Master/slave

Physical Characteristics

Dimension	Measurement
PCI Length x Width	17.27 cm x 10.67 cm (6.8" x 4.2"

Power Requirements

Specification	Measurement
PCI operating voltage	+5 V ± 5%
PCI power consumption	7.5 Watts 1.5A @ +5VDC

Environmental Specifications

Condition	Operating Specification	Storage Specification
Temperature	0° to 55° C (+32 to +131 F)	-40° to +85° C
Relative humidity	5 to 85% non-condensing (40° C, 16 hour dwells at extremes)	5 to 95% non-condensing 10° C/hour
Altitude	Up to 10,000 feet	Up to 35,000 feet
Shock	10g, 1/2 sine wave, 11 msec	60g, 1/2 sine wave, 11 msec
Vibration, peak to peak displacement	0.005 in. max (5 to 32 Hz)	0.1 in. max (5 to 17 Hz)
Vibration, peak acceleration	0.25g (5 to 500 Hz) (Sweep Rate = 1 octave/min.)	0.25g (5 to 500 Hz) (Sweep Rate = 1 octave/min.)

Appendix B

Ethernet Connector

The 8-pin RJ-45 connector for 10/100/1000 Mb/sec Ethernet is wired as shown:
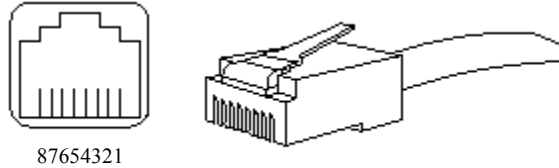

87654321

Figure 9: 8-Pin RJ-45 Connector (Front)

With the connection pins assigned as shown:

Contact	10Base-T Signal	100Base-TX Signal	1000Base-T Signal
1	TD+ (Transmit Data)	TD+ (Transmit Data)	BI_DA+ (Bidi Data)
2	TD- (Transmit Data)	TD- (Transmit Data)	BI_DA- (Bidi Data)
3	RD+ (Receive Data)	RD+ (Receive Data)	BI_DB+ (Bidi Data)
4	Not used	Not used	BI_DC+ (Bidi Data)
5	Not used	Not used	BI_DC- (Bidi Data)
6	RD- (Receive Data)	RD- (Receive Data)	BI_DB- (Bidi Data)
7	Not Used	Not Used	BI_DD+ (Bidi Data)
8	Not Used	Not Used	BI_DD- (Bidi Data)

Table 12: 8-Pin RJ-45 Connector Pin Assignments

Network Cabling Requirements

In order for your network to operate properly, you must use a category of network cabling that is appropriate for the data rate of the channel. For 10Mb/s operation, Category 3, or 5 cable is appropriate. When operating in 100/1000Mb/s or 100/1000Mb/s Full Duplex, a Category 5 cable should be used.

The maximum cable segment length supported at 100/1000Mb/sec speed, on Category 5 cable is 100M. Any single cable segment (adapter to adapter or adapter to network hub) must be within the 100M length requirement.

Appendix C

Glossary of Terms

The following terms are used throughout this guide.

Term	Meaning	Notes
10/100/1000	10, 100 and 1000Mbps on the same port.	The port will be running at the negotiated speed. See LEDs on the handle to determine the speed of operation
1000BaseT	Physical layer spec. for 1000Mbps Ethernet over various wiring specs.	
100BaseT	Physical layer spec. for 100Mbps Ethernet over various wiring specs.	
10BaseT	IEEE 802.3 physical layer spec. for 10Mbps Ethernet over 2 pairs of UTP wire	
CSMA/CD	Carrier Sense Multiple Access/Collision Detect. Protocol for carrier transmission access in Ethernet networks.	
Gigabit Ethernet	1000Mbps technology based on the 10BaseT Ethernet CSMA/CD network access method.	
Ethernet	IEEE-standard data link protocol that specifies how data is placed on and retrieved from a common transmission medium.	
Fast Ethernet	100Mbps technology based on the 10BaseT Ethernet CSMA/CD network access method.	
Hub	Connects 2 or more devices together in order for them to communicate on a network	
NIC	Network Interface Card, i.e. ITI-5100G	

Packet	Unit of information packaged in a predetermined structure for communications using Ethernet protocols.	
PCI	Peripheral Component Interconnect	Industry Standard Bus
RJ-45	The 8-conductor version of an RJ-11 (telephone, but wider).	
Router	Component which receives and transmits and forwards packets to their destinations via the shortest route possible.	
Switch	Hardware that routes packets across a network.	
UTP	Unshielded twisted pair	

Table 13: Glossary of Terms

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Appendix D

Software License

End-User License Agreement for Software
Warranty for Software and Hardware

Important- READ CAREFULLY: This End-User License Agreement ("EULA") is a legal agreement between you (either an individual or a single entity) licensee of the IntraServer ITIpci^{TM} SCSI Software being licensed by IntraServer Technology, Inc. ("ITI") for the software ("SOFTWARE PRODUCT" or "SOFTWARE") provided with the ITIpci^{TM} Host Adapter ("Host Adapter"). You may not use the Software except in conjunction with the Host Adapter. The SOFTWARE PRODUCT includes computer software, the associated media, any printed materials, and any "on-line" or electronic documentation. By installing, copying or otherwise using the SOFTWARE PRODUCT you agree to bound by the terms of this EULA. If you do not agree to the terms of this EULA, ITI is unwilling to license the SOFTWARE PRODUCT to you. In such event, you may not use or copy the SOFTWARE PRODUCT, and you should promptly contact ITI or your reseller for instructions on return of the Host Adapter and Software for a refund.

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Back-up:	You may make a single back-up copy of the SOFTWARE PRODUCT. You may use the back-up copy solely for archival purposes.
Right to Audit End User:	ITI reserves the right to audit you to verify compliance with the EULA.

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Separation of Components: The SOFTWARE PRODUCT is licensed as a single product. Its component part may not be separated for use on more than one computer.

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Reader's Comments

Mail to:

IntraServer Technology, Inc.
Seven October Hill Road
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Your comments and suggestions help us improve the quality of our publications.

I rate this manual on:	Excellent	Good	Fair	Poor
Accuracy (product works as manual says)	❏	❏	❏	❏
Completeness (enough information)	❏	❏	❏	❏
Clarity (easy to understand)	❏	❏	❏	❏
Organization (structure of subject matter)	❏	❏	❏	❏
Figures (useful)	❏	❏	❏	❏
Examples (useful)	❏	❏	❏	❏
Index (ability to find topic)	❏	❏	❏	❏
Page layout (easy to find information)	❏	❏	❏	❏

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